Hydrogels, The key to saving water in agriculture?

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Main Question?

How can hydrogels conserve water in Agriculture?

Sub questions:

1. How much water can the hydrogel absorb, and retain over time?
2. How much water can hydrogels retain in soil and help save water for agriculture?

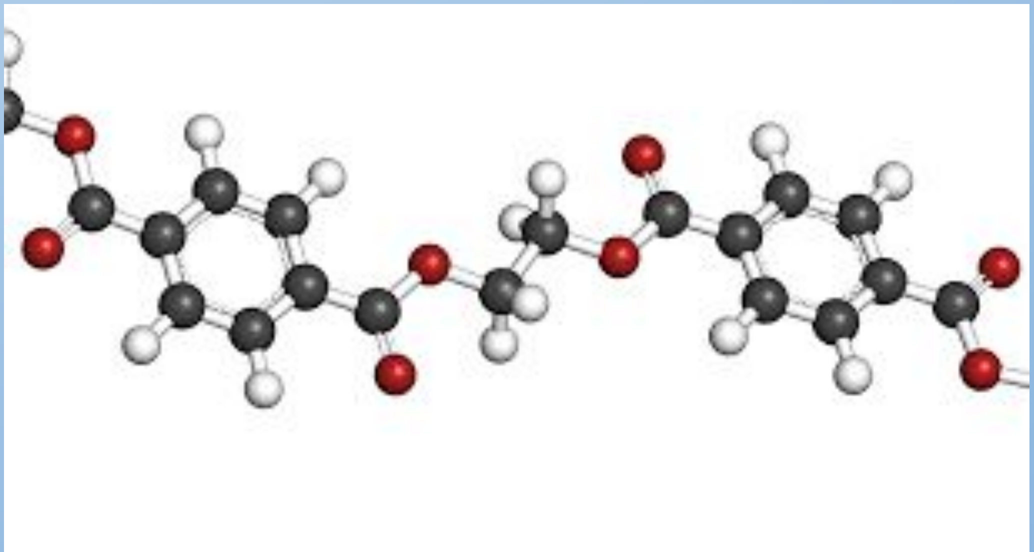
Questions about my experiment

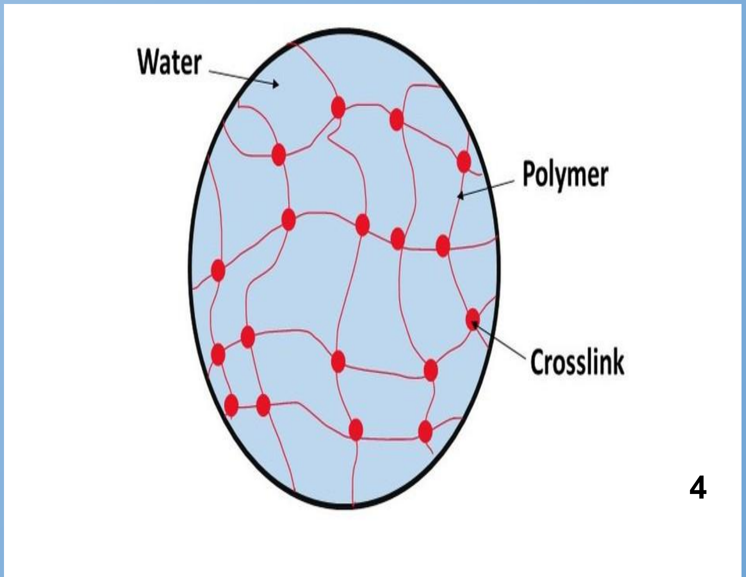
- What biodegradable hydrogel loses water the quickest?
- What hydrogel retains the water the longest?
- What hydrogel absorbs the most water?
- What hydrogel retains the most water in soil?
- What hydrogel would absorb the least amount of water?

Background Research

What is a hydrogel? Hydrogels are a material that hold water really well. They contain of big molecules that are surrounded in smaller molecules that are laid together in a certain pattern to hold water molecules.These hydrophobic/hydrophilic molecules act like a cage and trap water, this is called a polymer. When the polymers meet it is called a “Cross link.”**

How are hydrogels used in our daily lives? They are used for contact lenses, hygiene products, and even wound dressings. They are also used for drug delivery and tissue engineering.



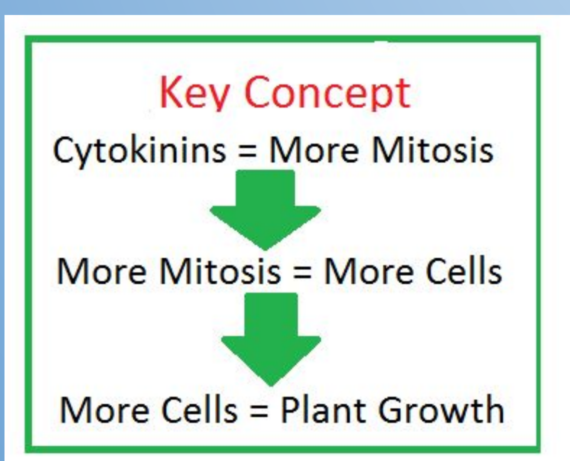


Background Research

Can agar help with plant growth? “Research grade agar is used extensively in plant biology as it is optionally supplemented with a nutrient and/or vitamin mixture that allows for seedling germination in Petri dishes under sterile conditions (given that the seeds are sterilized as well).” -Wikipedia

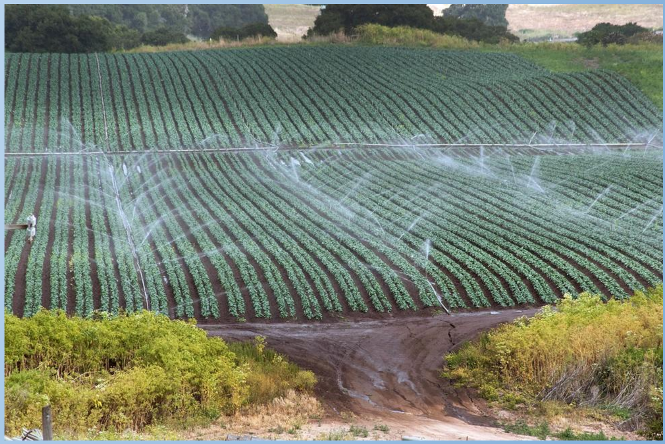
Agar is meant to contain all the nutrients that the new cells or tissues need to grow and become seedlings.

Agar generally holds the following hormones to stimulate optimal development:
1. Cytokinins (this hormone makes a plant produce mitos in the upper part of the plant, which splits cells into two identical cells which then leads to plant growth)
2. Auxins (these help with new root growth and increase cell division)



Background Research

How is it a possibility to use hydrogels to conserve water? Irrigating crop fields like this one bellow can take thousands of liters of water, a portion of which is evaporated from the unused water from the soil. Also plants transpire about 95% - 98% of the water they suck up through their roots, this means that they actually use 5% - 2% of their water. This means that the hydrogels might slowly release the water thus conserving the water and giving the plant what it needs. Or the roots can grow towards the hydrogel when they need water, acting like a fridge so when the plant needs water it can grow towards the hydrogel and take water when necessary. Lastly the hydrogel may absorb water from the soil faster than the plant or for the water evaporating thus it helps retain soil moisture.



What does H.E.C stand for? It stands for Hydroxyethyl Cellulose (This ingredient is one of the compounds of my hydrogel.)

How can roots move toward water?
Roots can sense the moisture in the soil.
They have specialized cells and tissues that can detect changes in water concentration. When the root detects a
water concentration of water it initiates a growth response.
The cells on one side of the root grow longer, causing the root to curve towards the direction of higher water concentration.

Background Research

What is the chemical compound for hydroxyethyl cellulose?

It is $(C2H6O2)n$ Meaning two carbon atoms, six hydrogen atoms, and lastly two oxygen atoms. The “n” at the end means that there are many HEC molecule stuck together.

Why is hydroxyethyl cellulose a gelling agent?

When HEC is added to water, the hydroxyethyl groups interact with water molecules through hydrogen bonding. This interaction causes the polymer chains to spread out and become entangled in the water molecules. This structure thickens the water and gives it a gel-like consistency.

Why is agar a gelling agent?

Hydrocolloid Property: Agar has a special property called hydrocolloid behavior. This means it can form a gel in the presence of water. Fact* Agar can also be transformed into plastic and used in many sauces.

Gel Formation:

When agar is heated in water, it dissolves to form a clear solution. However, when this solution cools down, agar molecules arrange themselves in a three-dimensional network. This network traps water molecules and forms a gel.

Variables

1. Manipulated: The different hydrogels
2. Responding:

   -what hydrogel absorbs the most water

   -What hydrogel retains the most water the longest
3. Control (for experiment 2): Container with just soil to measure evaporation rate.

   (There wasn't need to have one in experiment 1 because it was only needed to compare the data to the others)
4. Constants: Same container, same potting soil,same temperature of boiling water, same room temperature, same scale, same water, same measuring cup, and same cup that hydrogels were mixed in.

Hypothesis 1.0

If the hydrogels are placed in water, hydrogels absorb maximum water, and weights are recorded over 14 days, then the hydroxyethyl cellulose hydrogel will retain the most water overtime (over 14 days) because the strong repeating polymers made of glucose will trap the that water over time. Plus agar hydrogel can be reversible and turn into liquid with the cold temperature of the environment the experiment take place in, thus the agar hydrogel and HEC + Agar hydrogel will not hold the maximum or majority of its water over time.

Hypothesis 2.0

If three different hydrogels are placed in water and are given a chance to absorb water then agar hydrogel will absorb the most because agar contains special polymers that swell up to hold water as well as trapping it.

Materials

Kitchen scale
Agar powder, (60 grams).
Hydroxyethyl cellulose (HEC) powder, (60 grams)
Citric acid, (30 grams).
Water.
Kettle or device for boiling and easily pouring water
4-cup (1-liter) Pyrex measuring cup or other similar sized heat-resistant container
Spoon
Fork
90 x 15 mm petri dishes or small containers(30) [8oz]
Paper towel
Containers or bowls than can hold at least 1 cup of water (12)
Potting soil, preferably without (water-holding agents);
Small pots (16); seedling pots work well
Measuring cup or gradual cylinder, 60ml

Procedure phase 1 (creating the hydrogels)

*weigh containers weight before starting experiment

1. Gather materials
2. Label containers for which hydrogel will go in there
3. **First start by making the Agar hydrogel:**

- Get 40 grams of agar powder and 10 grams of citric acid and mix the dry ingredients in the heat resistant measuring cup.
- Next boil more than 500ML water in a kettle to (100℃)
- Pour 500ml of the boiled water into the cup and start mixing until it's very thick or hard to stir.
- When all citric acid and agar powder clumps are gone carefully pour 60 ml of hydrogel into small container, or tare container and pour 60 grams of hydrogel.

5. **Second make the HEC Hydrogel:**

- Repeat same method for the agar hydrogel except instead of using 40 grams of agar, use 40 grams of hydroxyethyl cellulose powder and 10 grams of citric acid.

6. **Third make the Agar and HEC hydrogel:**

- Mix 20 grams of Agar powder with 20 grams of Hydroxyethyl cellulose in a heat resistant measuring cup
- Next boil more than 500ML water in a kettle to (100℃)
- Pour 500ml of the boiled water into the cup and start mixing until it's very thick or hard to stir.
- When all citric acid and agar powder clumps are gone carefully pour 60 ml of hydrogel into small container, or tare container and pour 60 grams of hydrogel (pour 60 ml of hydrogel in each of the special containers for sub experiment #2 and 60 ml)

7. Let hydrogels cool for 3 hrs, but do not leave them for more than 48 hrs (put lids on them).

Procedure phase 2

(how much can the hydrogel absorb and retain over time)

1. After hydrogels are cooled, label containers.
2. Add 60 ml of water to all hydrogel container
3. Weigh hydrogel in container
4. Wait an hour for hydrogel to reach maximum absorption
5. Weigh hydrogel in container and subtract initial weight of container.
6. Enter data into spreadsheet
7. Then for 14 days record observations and and weight of hydrogel.

Procedure phase 3

1. Use fork or spoon and cut hydrogels into small pieces (the size of a pea)
2. Add 60 grams of potting soil to container
3. Then add 60 ml of water
4. Weigh container
5. Record weights and observations of containers for 14 days

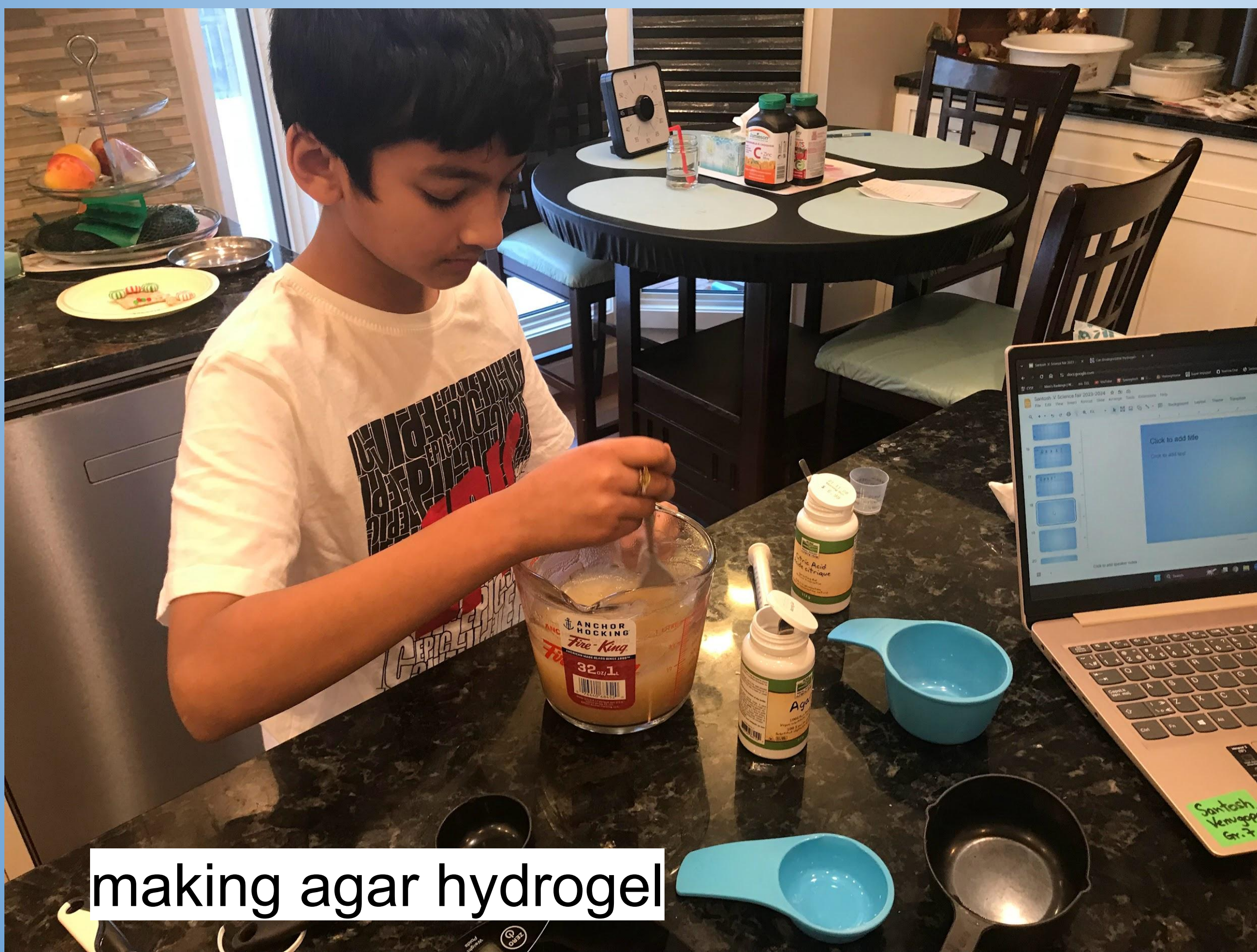
Qualitative observations for procedure phase 1

1. Agar: While making this hydrogel it was hard to mix as their were lots of big clumps of the dry ingredients. When making this hydrogel it smelled really bad sort of like a very dirty or unclean pool. 15 minutes after I poured the hydrogels I notice that is was a light yellow in colouration and it was the most opaque and I couldn't see through it at all. It settled in a lump

2. Hydroxyethyl cellulose: While making this hydrogel it was really easy to mix and lumps of the dry ingredients quickly mixed with the water. This hydrogel smelled like vinegar or some type of acid. 10-20 minutes later after I poured the hydrogel into the container I noticed it had lots of small bubbles near the surface and compared to the others it was really translucent and it settled all around the container

3. Agar + HEC: While making this hydrogel it was fairly easy to mix but was a little harder that HEC. There were some lumps from the dry ingredients but it was easy to mix.

measuring and putting wet hydrogels into containers.



making agar hydrogel

Hydrogels being cooled

Day 0

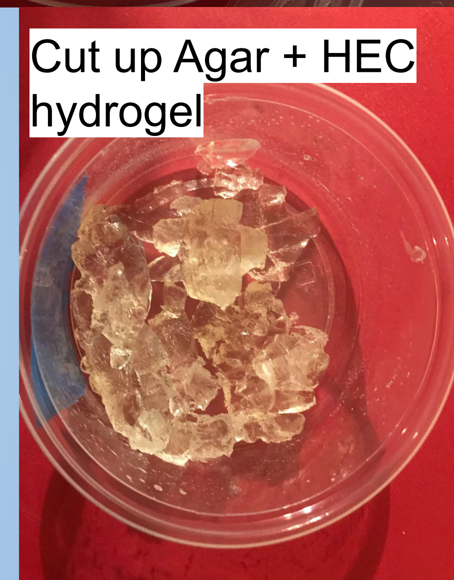
Hec: when soaking the HEC hydrogel in the 45th minute there was some puffy bits of hydrogel starting to expand outward. HEC hydrogel looked that it was swelling the most out of all the hydrogels. Also HEC hydrogel had lots of tiny bubbles. While doing experiment 2 and cutting the HEC hydrogel into pieces the hydrogel was very jiggly and felt a lot like JELLO™.

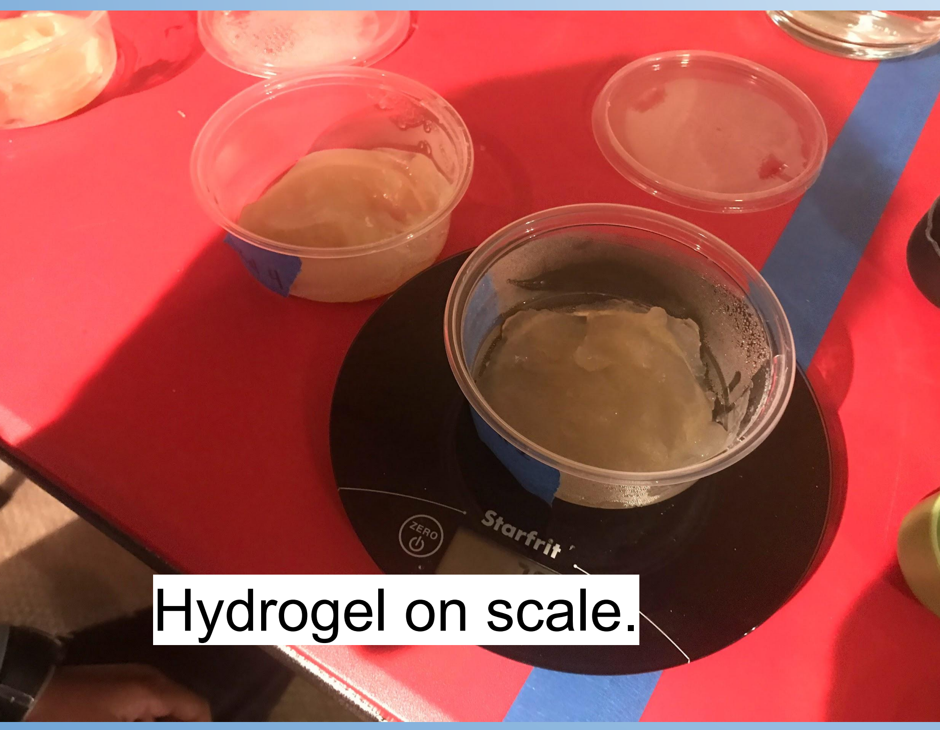
Agar: Agar hydrogel looked like it didn't absorb much water but over time I noticed that the water sitting on top of the hydrogel was less and less visible over time. It still had a stinky smell like in procedure phase 1. In experiment 2 it felt like a really firm fruit sort of like a ripe mango. It was the easiest to cut into pieces.

Agar + HEC: When soaking the hydrogel before and after it felt a little different as the hydrogel was less sticky at the start but became goopy and very sticky at the end. Just like the agar hydrogel it was hard to see major absorption. This hydrogel still had white dot/clumps of white in the hydrogel.

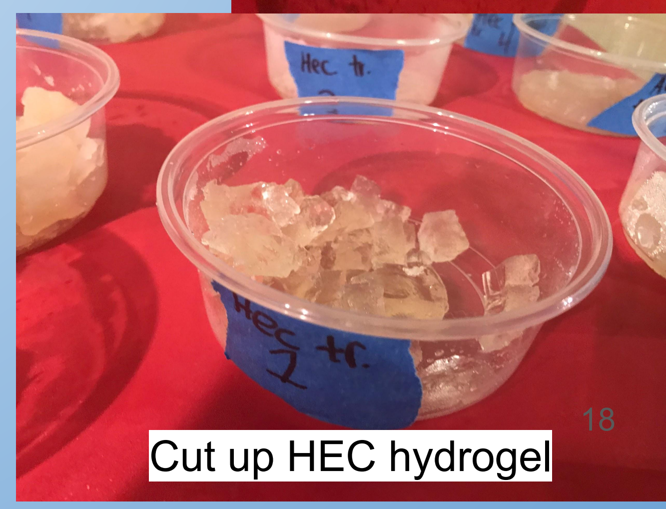
Me weighing hydrogel


Cut up Agar hydrogel


Cut up Agar + HEC hydrogel



Hydrogel on scale.



Cut up HEC hydrogel

Day 1-2

HEC: This hydrogel still had bubbles

Agar: In experiment 1 the hydrogel hardened significantly but not to the extent that it was super hard that it wasn't retaining moisture. Later I realized that the was hard layer around the outside but it was still moist and wet on the inside.

Agar + HEC: This hydrogel was still sticky and goopy but unlike agar and HEC this hydrogel did not settle and all the hydrogel was not touching around the container. White dots were still prominent throughout the hydrogel.

Day 3-7

Mold growth: On day 3 there was a little bit of mold growth on every container in experiment 2 but no mold growth on trials for Agar + HEC. The place with the most mold growth was agar trial 3 and 4.

HEC: this hydrogel lost the majority of the water on top. No noticeable changes other than the hydrogel was only a little bit dry and hard.

Agar: Was now very hard and not that squishy anymore

Agar + HEC: This hydrogel was not sticky anymore but it felt like agar at the start of the experiment.

Day 5 pictures

Day 8-9

The soil was fair and dry

First day that agar trial 1 (experiment 1) was dried and shriveled up and it light brown.

On day 9 Measurements were missed, so measurement were done in the early morning.

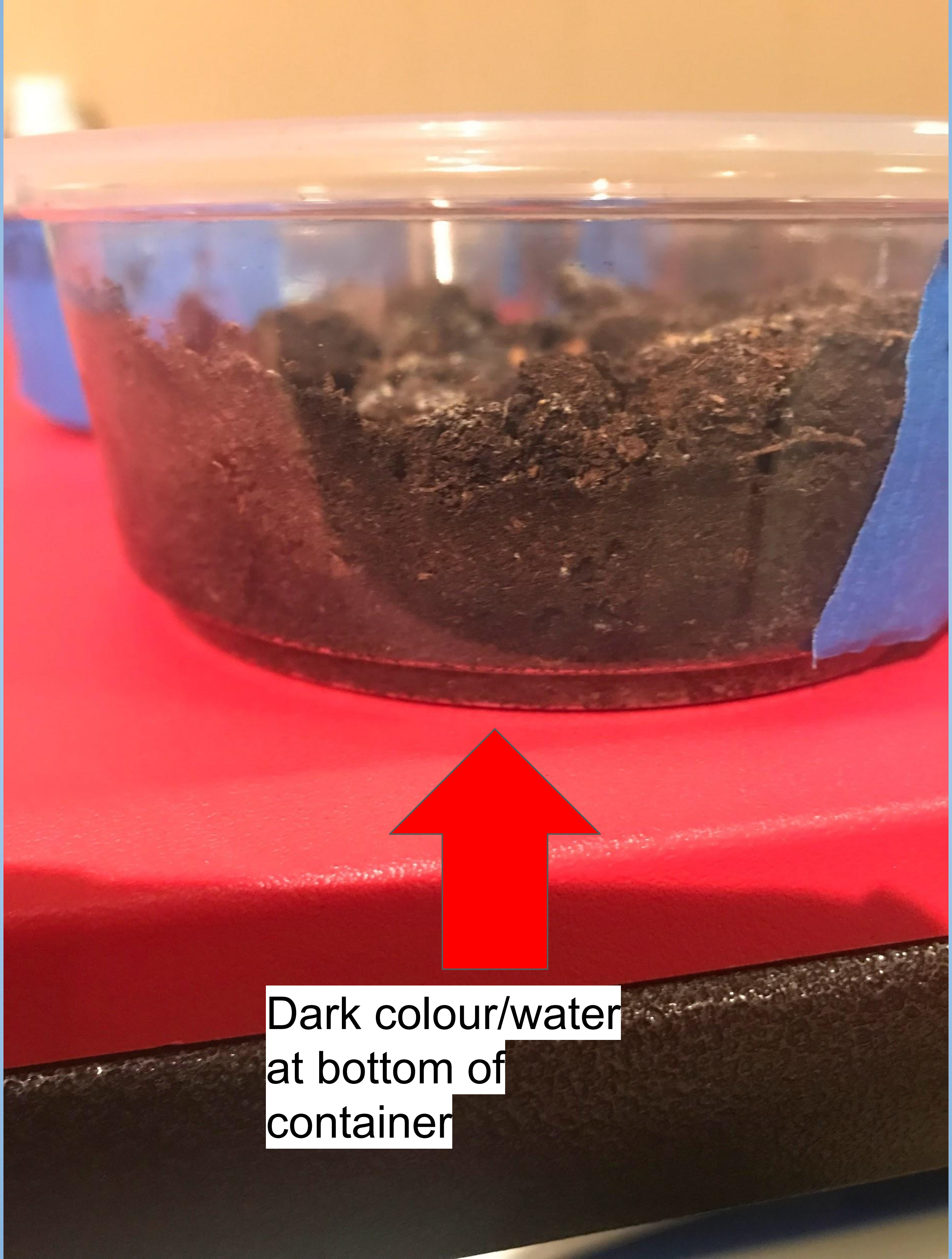
Day 8 pictures.

Day 10

All hydrogels are shrinking and HEC in peeled off of container (trial 3, 4)

HEC has water and dark color at bottom of container, also very rigid.

Agar is brown and size of finger.


Dark colour/water at bottom of container

Day 11

Agar: agar trial one (experiment 1) is rock hard and others are starting to solidify. Based on the data agar trial 1 evaporated all of its water (potential)

HEC: Hec trial 1 (Experiment 1) is the hardest out of them all. Hec for experiment 2, all the containers have lots of water at the bottom

Agar + HEC: in experiment 1 all of them are slightly squishy and still have prominent white dots in them.

Day 12-14

Agar + HEC: From day 12-14 this hydrogel had large white dots that were very hard. Overall every day there was noticeable shrinking every day. Also compared to agar its color still stayed the same with only a very small amount of the hydrogel changing colour.

HEC: Hec had the smallest change in appearance as it did not change colour over days 12-14 and only 1 hydrogel decreased in their size.

Agar: Agar's physical appearance changed the most, as it was very noticeable to see the different colours and size throughout day 12-14.

All hydrogels with a hydrogel that was measured incorrectly and was significantly smaller than the rest of the hydrogels in its group were the darkest throughout the experiment.

Day 14 hydrogels (Exp. 2)

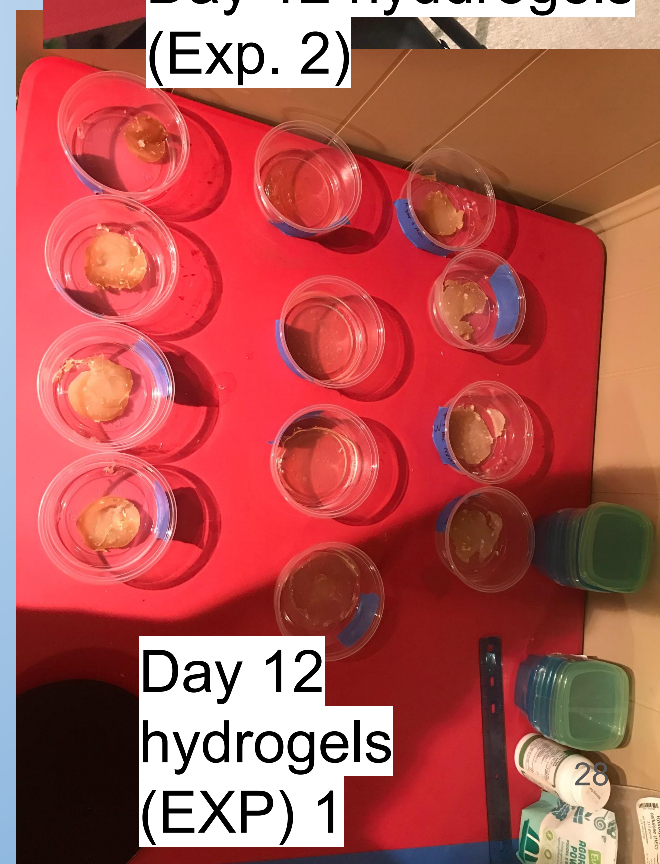
Mold growth

Day 13 hydrogels (Exp. 2)

Day 12 hyddrogels (Exp. 2)

Day 14 hydrogels (Exp. 2)

Day 13 hydrogels (Exp. 1)



Day 12 hydrogels (EXP) 1

Observations (data table for experiment #1)

Type of hydrogel	container weight (g)	Weight pre soaking (g)	Water + trial (g)	Weight after draining (g) day 0	day 1	day 2	day 3	day 4	day 5	day 6	day 7	day 8	day 9	day 10	day 11	day 12	day 13	day 14
Agar trial 1	8	66	115	69	61	53	45	36	30	25	21	17	15	15	15	15	14	14
Agar trial 2	8	79	129	81	76	70	64	51	52	46	42	35	32	30	26	24	20	19
Agar trial 3	8	72	119	75	71	66	61	56	51	47	42	36	34	31	27	25	21	20
Agar trial 4	8	67	117	69	65	60	55	51	46	41	37	30	29	26	22	20	18	17
HEC trial 1	8	75	123	85	77	68	61	53	48	40	33	24	22	18	17	16	16	16
HEC trial 2	8	69	120	79	74	69	64	58	53	48	44	36	34	30	25	21	18	16
HEC trial 3	8	65	110	75	71	66	62	56	52	47	42	34	32	28	24	21	19	17
HEC trial 4	8	61	107	71	67	63	59	53	48	43	38	31	29	25	22	19	17	16
Ag.+HEC tr. 1	8	70	111	79	70	64	57	50	45	39	34	28	26	23	20	17	15	15
Ag.+HEC tr. 2	8	65	113	73	68	62	56	49	45	41	37	31	30	27	24	21	19	17
Ag.+HEC tr. 3	8	74	117	83	77	72	66	59	55	50	45	38	36	33	29	25	22	20
Ag.+HEC tr. 4	8	65	106	73	68	62	57	51	47	41	37	31	29	25	23	20	18	16

Observations [data table for experiment 2]

Type of hydrogel	Weight before (no soil) [g]	with soil 50g & 60 ml day 0 (g)	day 1	day 2	day 3	day 4	day 5	day 6	day 7	day 8	day 9	day 10	day 11	day12	day13	day14
Con. 1	8	100	94	87	80	73	68	62	57	52	50	48	45	43	41	40
Con. 2	8	107	102	96	90	82	77	70	65	58	56	52	49	46	43	42
Con. 3	8	100	94	87	81	74	69	63	58	52	51	48	45	43	42	41
Con. 4	8	110	103	95	88	79	72	65	59	50	48	45	41	38	37	36
Agar trial 1	72	181	174	166	157	148	140	132	126	115	114	108	103	98	93	89
Agar trial 2	69	170	163	155	147	138	132	124	117	108	106	101	96	92	87	84
Agar trial 3	65	168	161	153	145	137	130	121	114	103	101	95	90	85	80	76
Agar trial 4	54	156	148	137	130	122	114	105	97	81	85	80	75	69	64	61
HEC trial 1	72	170	164	157	151	143	136	128	120	106	108	103	97	91	86	83
HEC trial 2	60	160	154	146	138	130	123	113	105	96	93	88	82	77	72	69
HEC trial 3	60	164	156	148	141	132	124	114	106	92	92	86	80	74	68	64
HEC trial 4	78	181	172	162	153	142	133	122	112	96	98	91	84	77	72	67
Ag.+HEC tr. 1	63	164	156	148	141	133	126	118	111	98	98	94	88	83	78	75
Ag.+HEC tr. 2	66	167	159	151	143	134	126	117	109	94	95	90	85	80	75	71
Ag.+HEC tr. 3	60	158	150	140	131	121	114	104	97	85	86	81	77	72	68	66
Ag.+HEC tr. 4	62	152	141	131	123	114	106	99	93	81	84	80	76	72	68	65

Analysis (for experiment 1)

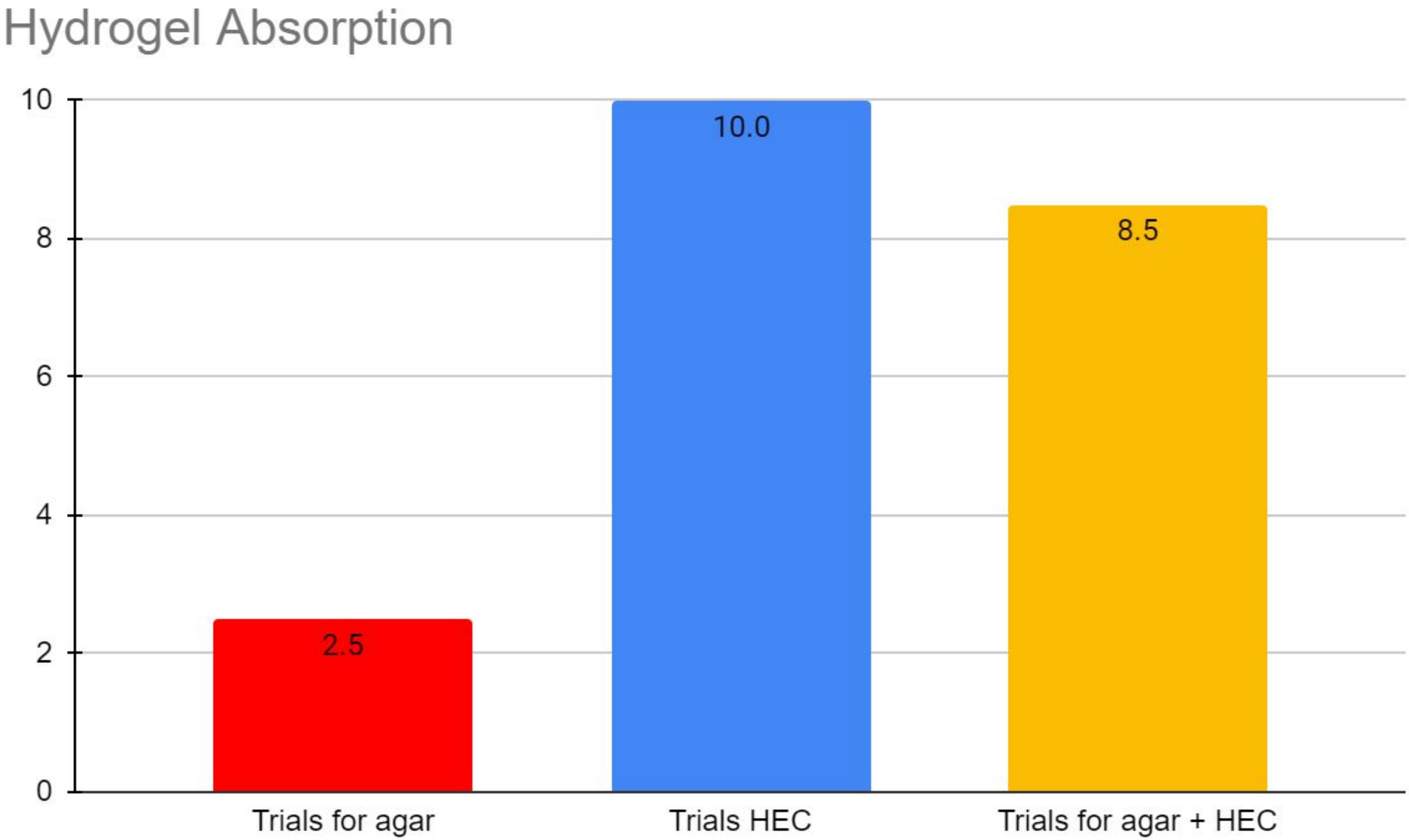
1. The weights and data of the hydrogels were entered into a spreadsheet table.
2. First it was needed to calculate the average weight for each day over each set of trials. For example, averaging all of agars trials for all 14 days.
3. Next it was needed to calculate the ***average of how much water was absorbed from the hydrogels***. This is done by finding all the differences from before and after absorption weights of a certain group of trials and then finding the average.
4. Then I need to calculate the ***average evaporation*** rate of the hydrogels. I do this by finding difference between the day zero and day 14 (from step 2). After that I divide the difference by 14 (days)
5. After, it was needed to calculate the ***average amount of water evaporated after 14 days***. This was calculated by subtracting the final day's weight from the initial weight at the start (from step 2)

Analisis (for experiment 1)

1. Lastly it was needed to calculate the the ***percent weight change***. This was calculated by dividing the average amount of water evaporated from the initial average weight (day 0) .
2. After that I need answer some of my "Questions about my experiment" (on slide 3)
3. And finally analyze of how and why the outcome of the experiment happened.

Down below ⬇️ is what I did for step 2

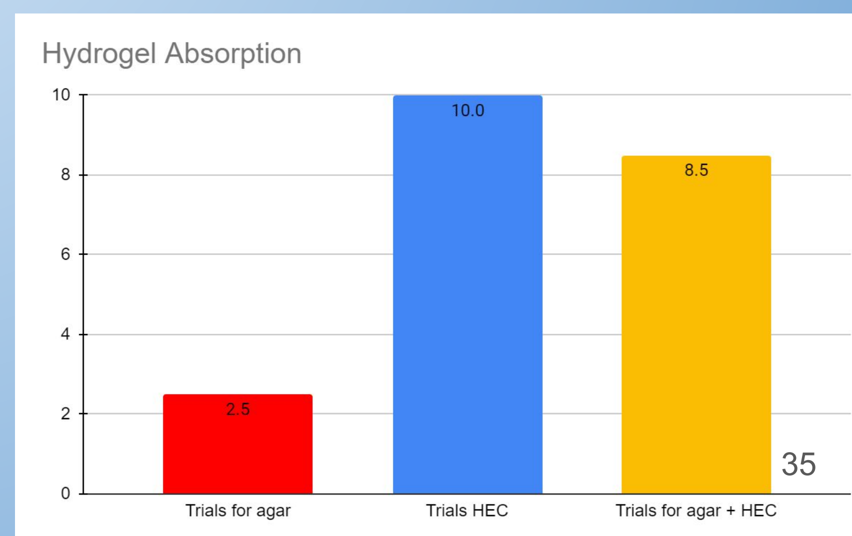
Weight after draining (g) day 0	Weight after draining (g) day 0	day 1	day 2	day 3	day 4	day 5	day 6	day 7	day 8	day 9	day 10	day 11	day 12	day 13	day 14
Agar	74	68	62	56	49	45	40	36	30	28	26	23	21	18	18
HEC	78	72	67	62	55	50	45	39	31	29	25	22	19	18	16
Agar +HEC	77	71	65	59	52	48	43	38	32	30	27	24	21	19	17

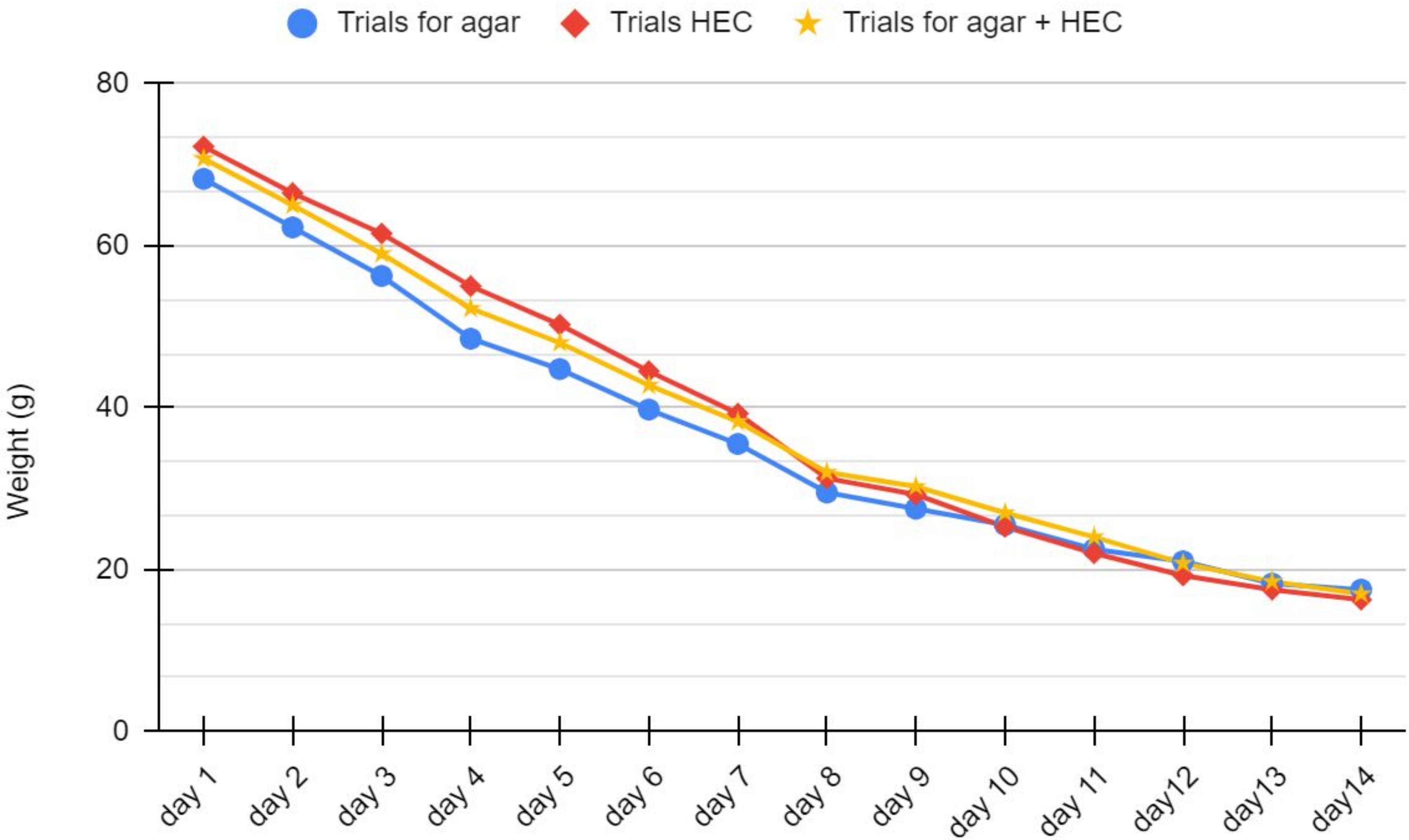


<u>Average absorption (Exp. 1)</u>

Average absorption (Exp. 1)

1. This graph shows the different average amounts of water absorbed from the hydrogels.
2. This graph shows that HEC hydrogel on average absorbed the most water, this hydrogel absorbed 10 grams of water.
3. Second was Agar + HEC absorbing 8.5 grams of water on average, and lastly Agar hydrogel absorbing 2.5 grams of water.
4. HEC and Agar + HEC hydrogels absorbed around 3-4 times the amount compared to Agar.



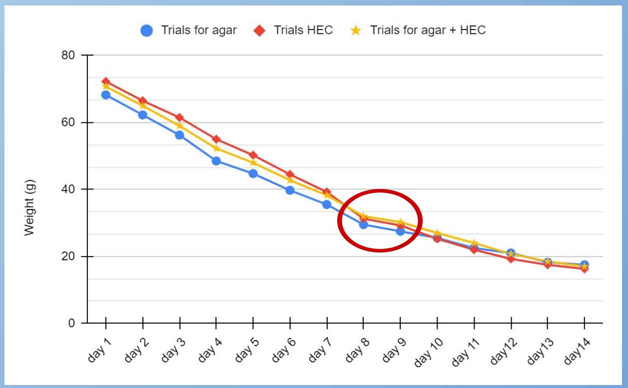


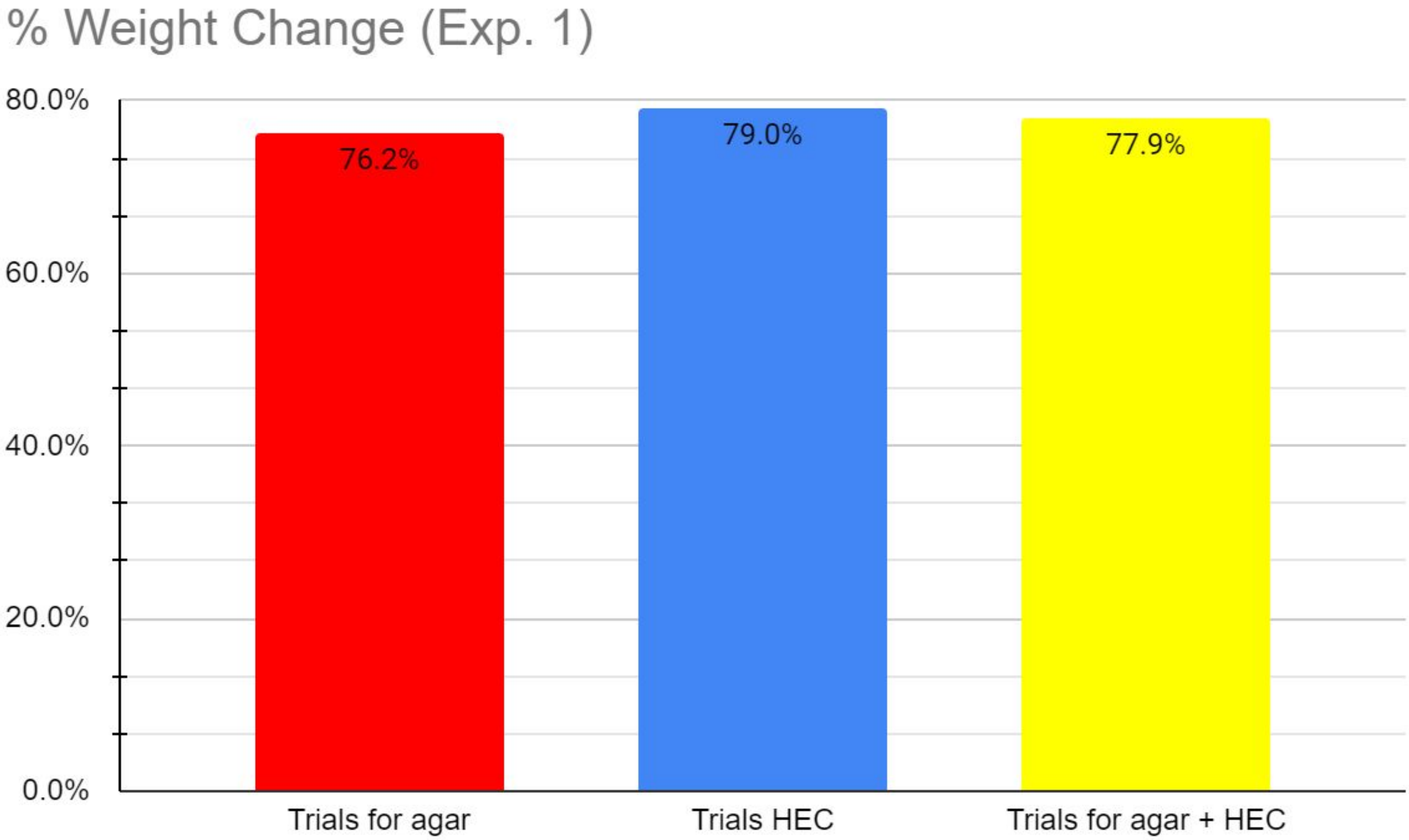
Evaporation rates/Average daily weight measurements for (Exp. 1)

Evaporation rates/Average daily weight measurements for (Exp. 1)

1. This graph shows the average daily weights for the three different hydrogels.
2. The slope of the graph represents the evaporation rates
3. Over all the hydrogels overall evaporation rates were very similar.
4. Agar hydrogel started at the lowest weight to begin with but it eventually retained the most water because it trend line was over the others. Second that retained the most water was Agar + HEC and finally HEC.
5. The kink in the graph circled below was caused by the wrong and inconsistent time of measuring the weights of the hydrogels.
6. The evaporation rate of agar was 4 grams of water a day while Agar + HEC's evaporation rate was 4.3 grams of water a day and lastly HEC's evaporation rate which was 4.4 grams a day.

Evaporation rate of grams of h20 per day	
Agar	4.0
HEC	4.4
Agar + HEC	4.3

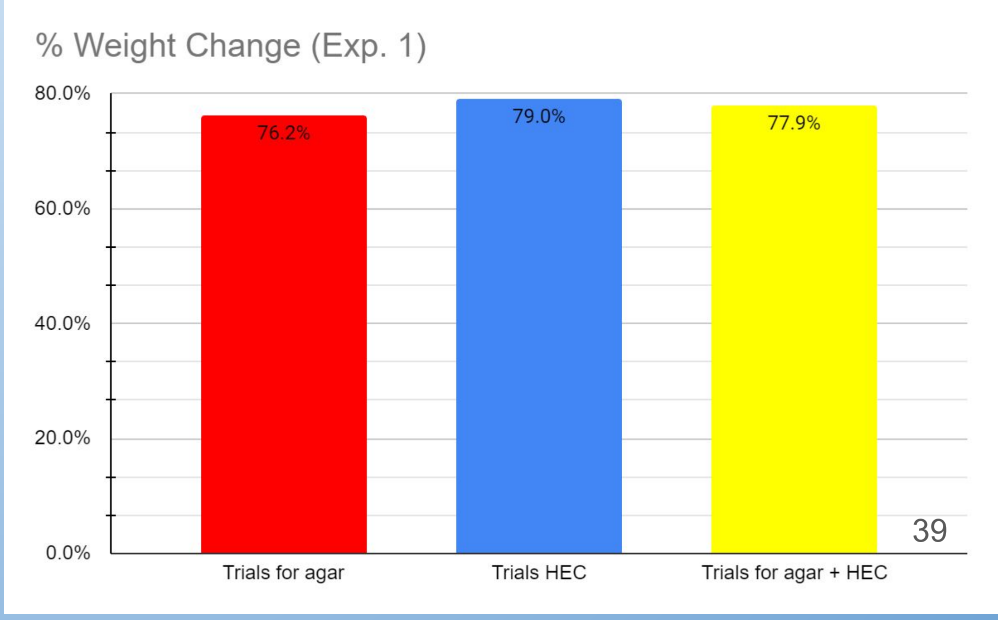




Average percent change weight (Exp. 1)

Average percent weight change (Exp. 1)

1. This graph shows the percent weight change from the start to the end of the experiment.
2. The percent weight change was very high and all the hydrogels on average lossed 77.71% of their water.
3. The results are the same as the graph previously explained and Agar hydrogel retained the most water as it lost 76.2%. Then Agar + HEC hydrogel as as it lossed 77.9% of it water, and finally HEC losing 79% of its water.

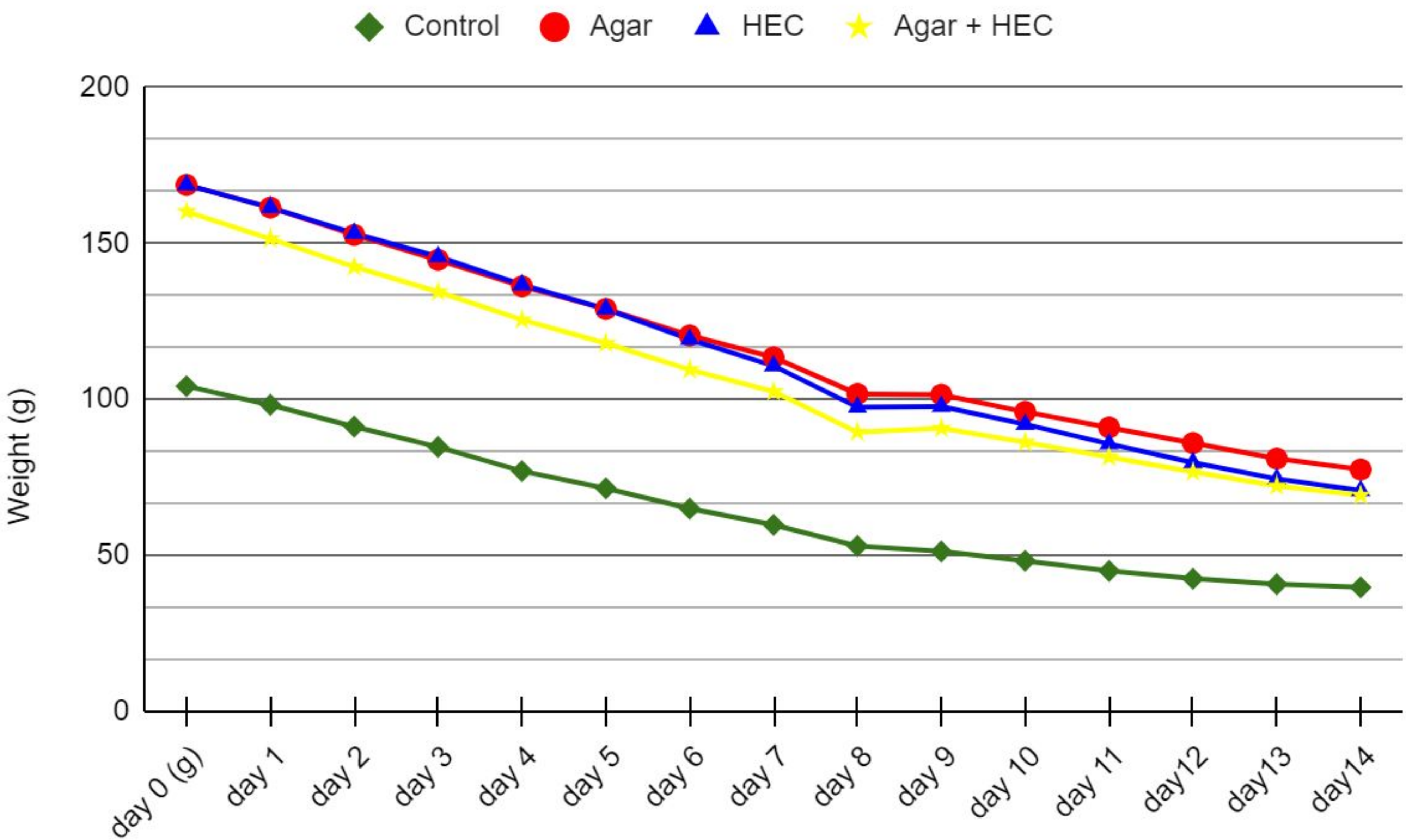


Analisis (for experiment 2)

1. First it was needed to calculate the ***average weight for each day*** over each set of trials. For example, averaging all of agars trials for all 14 days.
2. Then it was needed to calculate the average weight change. This is also the water the ***total water evaporated***. This is calculated by subtracting the final weight (from step 1) of the last day of the experiment (day 14) and subtracting it from day 0.
3. After, the next step was to calculate the ***average percent in weight change***. This is calculated by dividing the ***total water evaporated shown above*** ⬆️ from day zero's weight.
4. Next it was needed to calculate the ***evaporation rate***. This was determined by dividing the average weight change by 14 (days).
5. Finally then last step is to calculate how much ***water are the hydrogels are saving***. This is calculated by finding the difference between the average percent change in weight for the control and a certain/each hydrogel.

Down below ⬇️ is what I did for step 1.

	day 0 (g)	day 1	day 2	day 3	day 4	day 5	day 6	day 7	day 8	day 9	day 10	day 11	day 12	day 13	day 14
Control	104.3	98.3	91.3	84.8	77.0	71.5	65.0	59.8	53.0	51.3	48.3	45.0	42.5	40.8	39.8
Agar	168.8	161.5	152.8	144.8	136.3	129.0	120.5	113.5	101.8	101.5	96.0	91.0	86.0	81.0	77.5
HEC	168.8	161.5	153.3	145.8	136.8	129.0	119.3	110.8	97.5	97.8	92.0	85.8	79.8	74.5	70.8
Agar + HEC	160.3	151.5	142.5	134.5	125.5	118.0	109.5	102.5	89.5	90.8	86.3	81.5	76.8	72.3	69.3

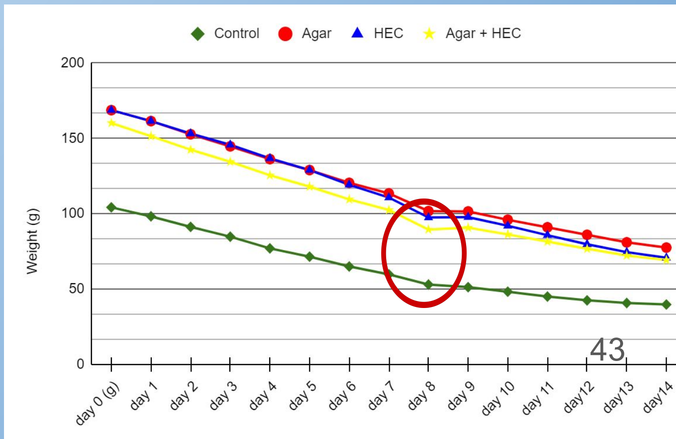


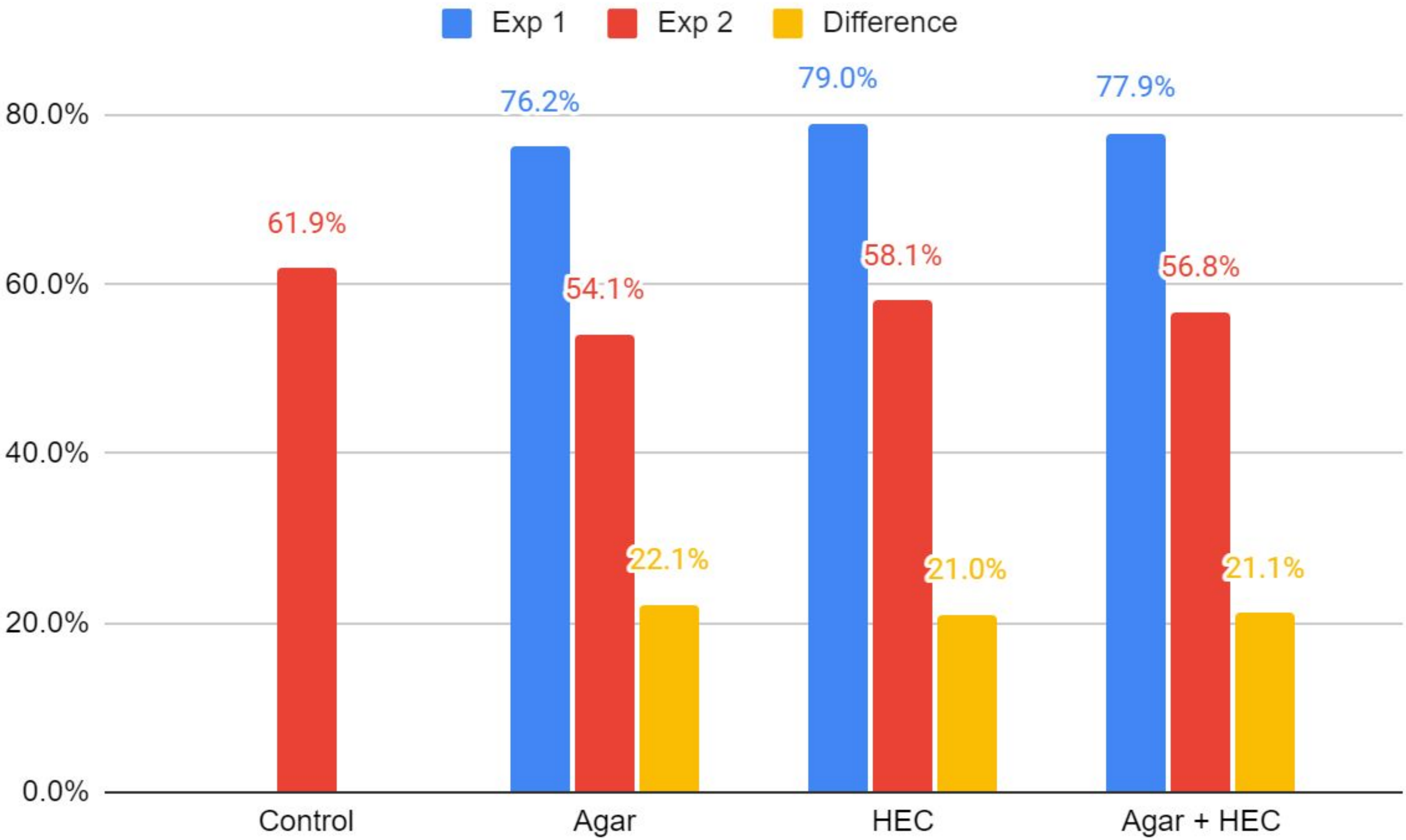
Evaporation rates/Average daily weight measurements for (Exp. 2)

Evaporation rates/Average daily weight measurements for (Exp. 2)

1. This graph shows the average daily weights for the three different hydrogels.
2. The slope of the graph represents the evaporation rates. The control was very similar to the hydrogels evaporation rates.
3. Over all the hydrogels overall evaporation rates were very similar.
4. Agar hydrogel started at the lowest weight to begin with but it eventually retained the most water because it trend line was over the others. Second that retained the most water was Agar + HEC and finally HEC.
5. The kink in the graph circled below was caused by the wrong and inconsistent time of measuring the weights of the hydrogels. The control had a less noticeable kink.
6. The evaporation rate of Agar was 6.5 grams of water a day while Agar + HEC's evaporation rate was the same at 6.5 grams of water a day and lastly HEC's evaporation rate which was 7 grams.
7. The control however had the lowest evaporation rate which was 4.6 grams of water per day.

Evaporation rate (g) of h20/day	
Control	4.6
Agar	6.5
HEC	7.0
Agar + HEC	6.5

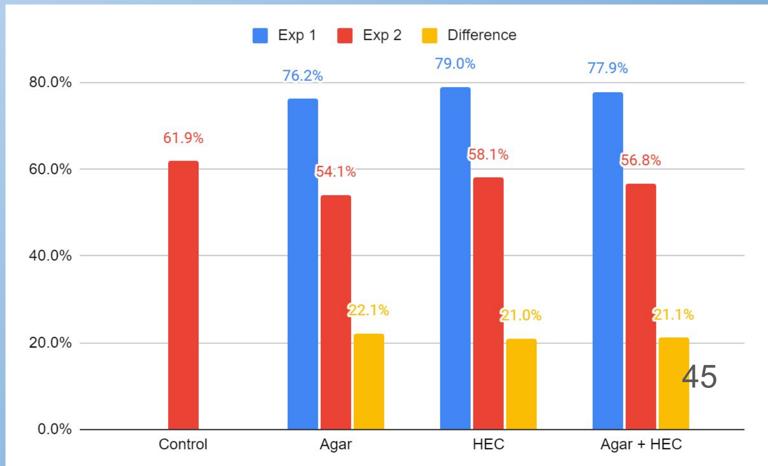


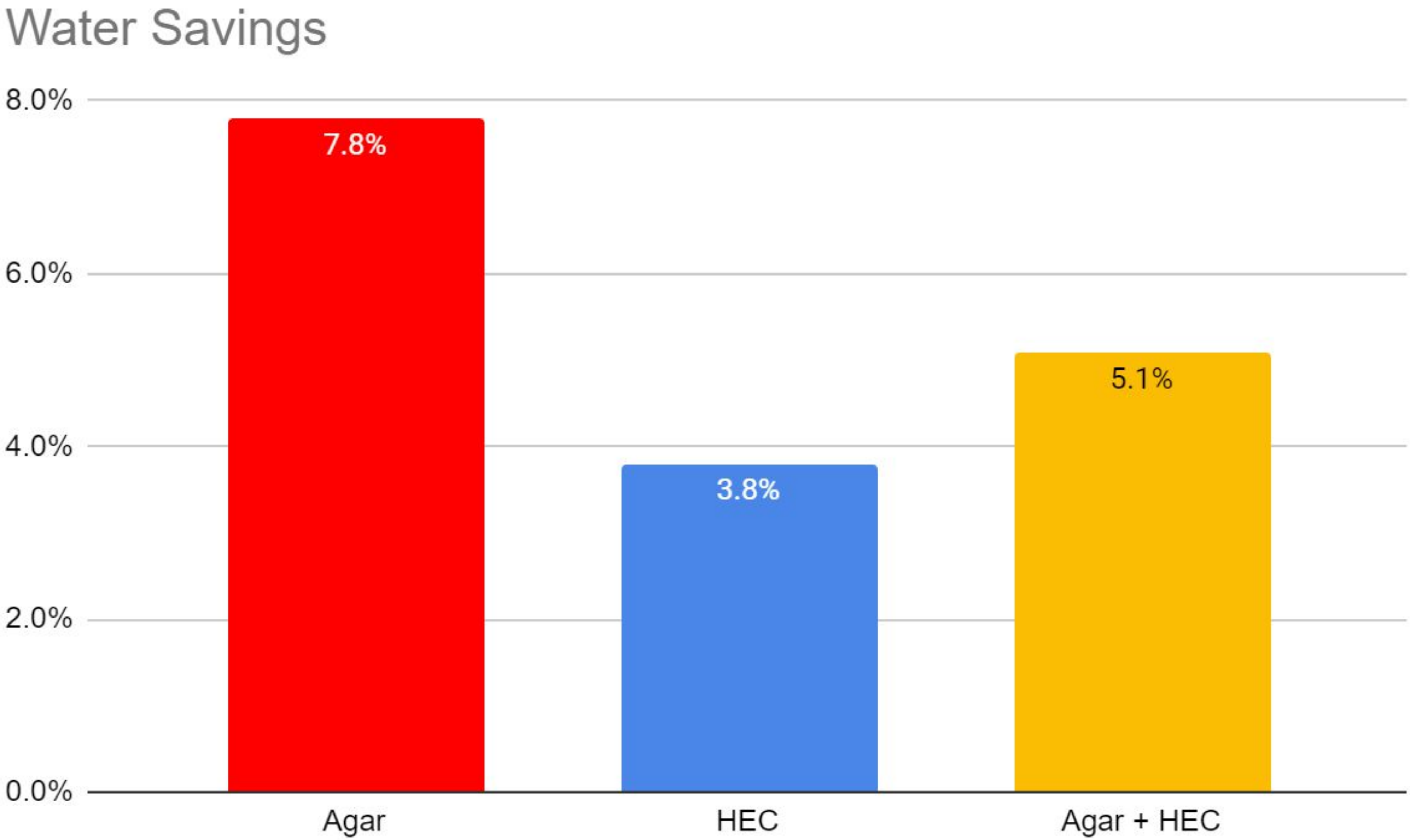


<u>Percent weight change (Exp. 2)</u>

Percent weight change (Exp. 2)

1. This graph shows the average percent weight change for Exp. 1 and 2 and also compares the difference between them.
2. In this graph for Exp. 1 percent weight change was about 20% higher than Exp. 2. This means that Exp. 1 had more water evaporate over the test time. This could be because the soil traps the water released from the hydrogel leading to a lower evaporation rate.

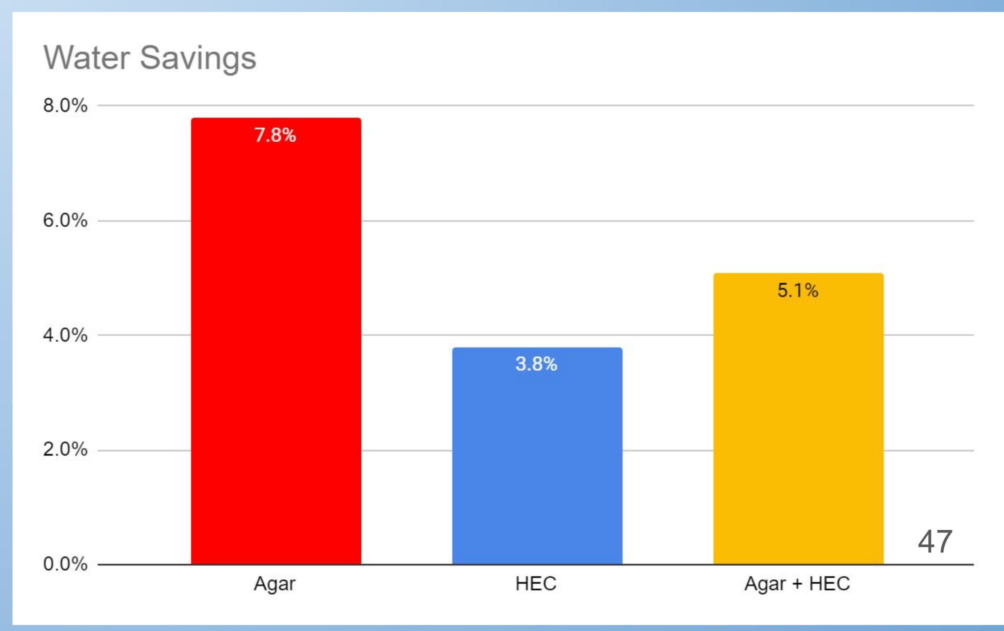




WATER SAVED! (Exp. 2)

WATER SAVED! (Exp. 2)

1. This graph shows how much water each hydrogel saves compared to the control.
2. This graph shows that agar hydrogel saves the most water as it save approximately 8%
3. Second was Agar + HEC saving 5.1% water
4. And lastly was HEC saving 3% water.



Conclusions (Exp. 1, Average absorption)

In conclusion my **hypothesis** was wrong and HEC hydrogel absorbed the most water, second Agar + HEC hydrogel and lastly, Agar hydrogel. HEC hydrogel may have a higher solute concentration than agar. The main reason why it absorbed the most water is that HEC consists of a hydroxyl (OH) group and an ethyl (C2H5) group. When these chemical compounds mix they make a highly soluble polymer that is very strong and hydrophilic. Also HEC is a polysaccharide which means it has long polymer chains made of repeating glucose molecules.

Average percent weight change (Exp. 1)

In Conclusion Agar hydrogel retained the most water losing only 76.2% of it water the second came Agar + HEC losing 77.9% of its water and finally HEC hydrogel losing 79% of its water. HEC might have not have retained lot of water because its long polymer chains might have not been very strong. And agar hydrogel polymer chains are stronger than HEC polymer chains. Also Agar polymer chains are made up of different material than HEC polymer chain made of glucose. Agar polymer chains might be more hydrophilic compared to HEC.

Conclusions (Exp. 1, Evaporation rates)

In conclusion Agar hydrogel had the lowest evaporation rate, then Agar + HEC hydrogel and lastly, HEC. Agar lost about 4 grams of water per day, then Agar + HEC hydrogel as it lost 4.3 grams of water a day, and last HEC as it lost 4.4 grams of water per day. Although the evaporation rates are very similar and close this proves my hypothesis wrong as I thought HEC hydrogel was going to retain the most water. Agar hydrogel retained the most water because, its polymers contain small molecules that absorb water into the molecule as well as strong main polymers that trap water. This is more efficient compared to HEC and Agar + HEC hydrogel.

Conclusions (Exp. 2, evaporation rates)

In conclusion Agar had the smallest evaporation rate compared to the other hydrogels. Just like Exp. 1 Agar hydrogel had the lowest evaporation rate compared to the other hydrogels. Agar hydrogel retained the most water compared to the rest of the hydrogels. For the control it lost 4.6 grams of water per day which was way lower than the rest of the hydrogels.

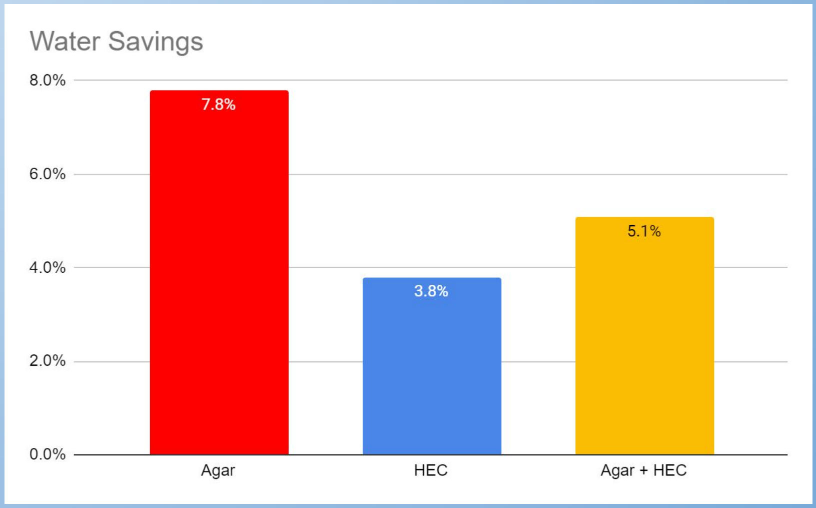
Evaporation rate (g) of h20/day	
Control	4.6
Agar	6.5
HEC	7.0
Agar + HEC	6.5

Conclusions (Exp. 2 ,% weight change)

In conclusion Agar hydrogel had the lowest percent in weight change because like experiment 1 Agar hydrogel might of had stronger polymers chains that traps water better than HEC and Agar + HEC hydrogels. The percent weight change in experiment 1 was on average about 21% higher than experiment 2. This might might have occured because the soil could of trapped some water that could have evaporated from the hydrogel.

Conclusions (Exp. 2, Water Saved!)

In conclusion Agar hydrogel saved the most water. When compared to the control Agar saved 7.8% water, second Agar + HEC hydrogel saving 5.1%, and finally HEC saving 3.8%.



Sources of error.

1. Measurement Error: In this experiment a very big source of error was measurement error because, when pouring hydrogels into the containers the hydrogel were stick and a large proportion of the hydrogel would sometimes stick to the measuring cup.
2. Measurement of of dry ingredients: While measuring the dry ingredients for the hydrogels some hydrogels were inconsistently measured because the scale had a hard time measuring the dry ingredients and going back and forth between different weights.
3. Stirring and letting: While stirring each hydrogel it was slightly inconsistent because I stirred some hydrogels faster or stirred the hydrogel more times compared to the others.

Applications

Why should we save water in Canada? We should save water because:

1. We could save an important resource and money. We could saving money by not having to ship lots of water to different places in our province/ or in our city.
2. We could save the conserved water when experiencing drought. So when we desperately need water and cannot get water we used the saved water for these occasions so people do not suffer from water scarcity.
3. In British Columbia and other places in Canada, there are many wildfires that happen more often, yearly. We could use the saved water to put out these fires.
4. When we save water used in agriculture, these is more water in the natural environment. Every time we use water for our toilets and household appliances our water goes to a wastewater treatment plants, and then from there the water goes into the rivers. This then pollutes our water thus makes our water dirty and unsafe for wildlife.
5. When we conserve water from agriculture, we can save our power and resources. Everytime we get clean water it is because of a wastewater treatment plant. This cleaning facility cleans our water, but takes lots of power to do so. If we minimise our water consumption (gardening), our wastewater treatment plants will not have to clean lots of water and save energy.

Applications

If all farmers in Alberta used hydrogels for agriculture, they could save 7.8% of their water use.

- Agriculture in Canada uses about 1.2 billion cubic meters per year
- Alberta uses 39% of Canada's agricultural water use
- This leads to Alberta consuming 468 million cubic meters for agriculture (1.2 billion cubic meters x 0.39)
- If Alberta farmers use hydrogels, they could save 36,504,000 cubic meters per year, or 36,504,000,000 litres per (468 million cubic meters x 0.078)
- If all farmers in Canada use hydrogels, they could save 96,600,000 cubic meters of water per year (1.2 billion cubic meters x 0.078)

The statistics above are from 2021

Applications

If farmers used Agar hydrogel for all of their crops:

- If all farmers in Alberta used agar hydrogels, they could save approximately $109,150,610.4 per year (One cubic meter of water for agriculture costs $2.9901 dollars in Alberta. Then It needed to multiply $2.9901 x 36,504,000 cubic meters)
- This money could go toward many things. A list of things the money could go toward are:

1. Healthcare - hire over 300 new family doctors ($340,000 per doctor)
2. Education - could built 4 new schools ($24 million per school)

Other examples are:

3. Fixing more roads
4. Funding Environmental protection agencies
5. Build more protective area's for wildlife parks
6. Improving the condition in first nation reserves

Application

How many people can the water conserved feed:

- The average person in Alberta uses 215 liters of water a day. For a year they consume around 78,475 liters of water per year. This means with all the water conserved with hydrogels, in all of Alberta this could give water to 465,046 people for a year (36,504,000,000 liters ➗78,475 liters for year per person).

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